One of the most interesting and instructive parts of this most interesting book is that contributed by Dr. J. H. Moore on the radial velocity of a star. This is very clearly written and to those who are not familiar with the work of the spectroscope is of the utmost value. One statement that makes more evident the difficulties that beset this wonderful instrument—the spectroscope—is that "When stellar spectrographs of three prism dispersion are used in conjunction with large refractors or reflectors, the combined instrument delivers to the photographic plate probably less than two per cent. of the light incident upon the telescope objective." Yet, with all the drawbacks that are so clearly set forth in Dr. Moore's valuable article, results that seem almost like magic are obtained when all the multitudinous precautions are taken into account. It is a happy combination indeed that places before the reader two such splendid accounts of the results of visual and spectroscopic observations of the binary systems of stars. When one has read Dr. Moore's account of the sources of error in the spectroscope and the ingenious devices that have been brought to bear upon their prevention or elimination, one can but express the sincerest admiration for the work of those who have made the spectroscope the magician's wand that it now seems to be.

Yerkes Observatory, E. E. BARNARD.
Williams Bay, Wisconsin,
May 15, 1919.

PAPERS AND ABSTRACTS OF PAPERS TO BE PRESENTED AT THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC AT PASADENA, JUNE 19-20, 1919.

As already announced in these PUBLICATIONS, the Astronomical Society of the Pacific will meet with the Pacific Division of the American Association for the Advancement of Science at Pasadena, on June 19-21. Two sessions will be held for the presentation of scientific papers, both at Throop College, the first from 10 to 12 on Thursday morning, June 19th, the second from 9:30 to 12 on Friday morning. At the second session a number of papers of interest to physicists as well as astronomers will be read and the members of

the Physical Society (which holds but one session, Thursday morning) are specially invited to be present. Throop College invites all members of the Division and affiliated societies to partake of luncheons served in the college dormitory on Thursday and Friday, June 19th and 20th.

No afternoon meetings will be held by the separate societies, but all members are invited to attend the general meetings of the Division and participate in the two Symposia which have been arranged. The first, on Thursday afternoon, will be on *The Exploration of the North Pacific Ocean.* Eight men, qualified by experience to treat of them briefly and succinctly, will introduce as many topics of great scientific and economic interest, and a general discussion will follow. The general subject for Friday afternoon is *Scientific Education in a Democracy.* President Scherer of Throop College will present the opening paper on *The Dependence of a Community on Scientific Experts,* and will be followed by six other speakers introducing such topics as *The Responsibilities of the Scientist, Must Learning be Mediocre in a Democracy?* etc. It is hoped that many members will take part in the discussions of all of the papers.

On Thursday evening the retiring president of the Pacific Division, Dr. D. T. McDougal, will deliver his address on *Growth of Organisms.* Following the address a public reception will be held. On Friday evening, Dr. S. D. Townley, of Stanford University, will give a public address on *Earthquakes on the Pacific Coast of North America.* These evening meetings will be held in the Palm Room of the Hotel Maryland.

An excursion to the summit of Mount Wilson is planned for Saturday, June 21st. Automobile stages will leave the Observatory offices at about 10 A. M. and will return to Pasadena in season for dinner. Delegates wishing to remain overnight on the mountain may secure quarters at the Mount Wilson Hotel by making arrangements in advance. An opportunity will be afforded for observation with the 60-inch telescope and it is probable that the 100-inch reflector may be utilized to some extent.

On the following pages the astronomical papers to be presented are given in full, or in the form of abstracts of greater or less length. The arrangement here is one of convenience and does not indicate the order of the actual program. Some of the papers may be read by title only, to afford time for discussion of the others.

Stereoscopic Photographs of the Solar Atmosphere

BY GEORGE E. HALE

An illustrated account of methods and results, indicating the precaution necessary to avoid pseudo-effects.

Are the Wave-Lengths of the Atmospheric Absorption Lines Variable?

BY CHARLES E. ST. JOHN AND HAROLD D. BABCOCK

In 1915 Professor Perot published a short account of observations he had made upon wave-lengths of lines in the absorption spectrum of the Earth's atmosphere. Using solar lines as reference standards he found that oxygen lines in the B group appeared to undergo a diurnal variation of wave-length amounting to a change of about 0.030 A. Recent observations made both on Mount Wilson and at Pasadena by two distinct methods, have failed to confirm the supposed variation.

On Radiation and the Age of Stars

BY HARLOW SHAPLEY

The long-standing disagreement between physical astronomy and geology as to the duration of solar radiation and the consequent age of the Earth, has as its basis on the physical side the assumption that the Sun's heat, flowing uniformly at the observed rate in all directions, comes from recognized sources—from gravitational contraction (generally admitted to be the most important source of energy), from in-falling meteorites, radioactivity, etc. In the case of the Sun these sources can supply for only a few million years the observed flow of heat, and in the case of the truly gaseous stars the total duration of the giant stage is limited to some thousands of years, according to computations by Eddington and others.

The data of geology, however, particularly the recent work on rhythms in denudation and sedimentation and on the radioactivity of rocks, are decidedly opposed to a short-time scale for the Sun and Earth. Similarly for the giant stars, the recent results from globular clusters and Cepheid variables appear decisive against former estimates of age. For instance, the period-luminosity correlation for Cepheids, as well as the observed constancy of their periods, would be impossible if the source of radiant energy for these giants is mainly gravitational. The dimensions now assigned to the galactic system, the distribution and stellar content of

globular clusters, and the fact that their star-colors are independent of relative distance, are all likewise opposed to the short-time scale. It appears from present geological and astrophysical evidence that the duration of the life of stars is probably several hundred times the interval given by the older physical theory.

The discord between the data of observation and the theory that gravitational contraction is the chief source of energy may possibly be accounted for in two different ways; but either of the following hypotheses would encounter some serious difficulties (perhaps not insuperable) with accepted physical properties of matter.

(1) If the radiation from the Sun and stars is actually greater in the direction of the Earth and other celestial bodies than in "empty" directions, then the amount of radiation measured at the Earth's surface has led us to infer a dissipation of solar energy that is too high and to deduce a life for Sun and stars that is too short. Such a hypothesis need involve only recognized sources of energy, and it would alleviate the difficulty with the time scale, would point to a better conservation of radiant energy, and might clear up some outstanding astronomical phenomena (altho simpler explanations may be found later). The supposition, however, of radiation wholly restricted to solid angles subtended by matter, altho in some respects preferable from the standpoint of a corpuscular theory of radiation, is hardly tenable because of observed phenomena of planetary temperatures and for other reasons. The supposition that radiation is merely somewhat concentrated between bodies appears to avoid most of these difficulties.

(2) If, as generally accepted, radiation flows uniformly in all directions, the amount of energy being dissipated from Sun and stars is so great that sources hitherto undiscovered must be invoked. Various expedients have been suggested, such as sub-atomic energy and the cancellation of mass. Perhaps a strong point in favor of such an interpretation is the probability that the very exceptional conditions within a star considerably modify the operation of ordinary physical laws for which we know the behavior at moderate temperatures only; and probably the greatest difficulty with this view is the necessity that the hypothetical source of internal energy must supply heat at just the rate required for radiation, in a manner similar to that of the gravitational contraction of a gas.

But whatever the solution of the energy problem and its significance for theories of radiation, on the basis of existing astronomical evidence it now appears that the disagreement between the long- and short-time scales must be decided in favor of an exceedingly prolonged history for sidereal systems, permitting a relatively slow evolutionary development for stars and planets.

The Spectrum of RU Camelopardalis

BY A. H. JOY

RU Camelopardalis ($7^h10^m.9, +69°54'$: 1900) is one of the variable usually classed among the Cepheids altho its light curve has some peculiarities which have called for special consideration. The range of light variation is 0.9 magnitude and the curve is symmetrical with a period of 22.2 days. The minimum is rather sharp and shorter in duration than in the case of the normal Cepheid.

Shapley, in an extended investigation[1], has studied the light curve and suggests that the variation in light may be due to the rotation of a single ellipsoidal body.

Four spectrograms of the star have been secured with the 60-inch reflector and the single-prism spectrograph with a camera of seven inches focal length.

Plate	Date	G. M. T.	J. D.	Phase From Min.	Hydrogen Lines
7873	1919 Feb. 13	$19^h.3$	242 2003.8	2.8 days	Bright
7971	Mch. 17	19 .9	2035.8	12.6 days	Dark
8019	Apr. 9	16 .9	2058.7	13.3 days	Dark
8122	Apr. 20	17 .0	2069.7	2.2 days	Bright

The phases are computed from the elements of Luizet[2] Min. = 2417610.96 +22.172 days.

The unusual and unexpected character of the spectrum for a variable of short period calls for especial comment. It shows all the general characteristics of type R. The four variables of this type with known period are all long-period variables, the average for the four being 396 days, and have a large range of light variation. The maximum strength of the spectrum lies between λ 4737 to λ 4850, and the characteristic carbon absorption at λ 4700 is clearly marked altho not prominent. The *g* group at λ 4308 shows strong absorption about equal to that of type Ko. The spectrograms are all well exposed and the density is good as far as λ 4215, where the light is sharply cut off by the carbon absorption band.

[1] *Laws' Observatory Bulletin*, No. 21, p. 71.
[2] *A. N.* 4614.

Above this point the spectrum is very weak·altho it can be seen farther to the violet in all cases, and one plate can be measured to λ 4000.

It is of interest to note that the plates taken at minimum of light, assuming that the elements are correct, show bright hydrogen lines while those at maximum show the usual absorption lines. Hβ, Hγ, and Hδ are all bright with strength decreasing from red to violet contrary to variables of type Md. Two of the R-type long-period variables mentioned have been observed at Harvard[3] to have Hβ and Hγ bright, presumably at maximum.

The absorption lines of hydrogen are of about the same strength as in type G8. There may be a number of bright lines in the spectrum other than those of hydrogen but this is as yet uncertain.

Preliminary measures show that the velocity is variable with the maximum velocity of approach at maximum of light as in the case of the Cepheid variables, the range being about 45 km. This evidence appears to be opposed to the suggestion that the variation of light is the result of the rotation of a single ellipsoidal body. The bright hydrogen lines give larger negative velocities than the absorption lines at minimum of light, their behavior thus corresponding to that well known in the case of stars of type Md.

So far as may be judged from these spectrograms of rather low dispersion the character of the lines other than those of hydrogen is very similar to that of the lines for typical Cepheids, and the strength of the enhanced lines indicates that the star is intrinsically very bright. The lines are sharp and show no marked variation between maximum and minimum of light.

Influence of Color in the Determination of Magnitudes

BY FREDERICK H. SEARES

It has long been recognized that stellar magnitudes determined by visual methods depend upon the color perception of the eye of the observer. Similar differences arising from the selective absorption exercised by the glass of the objective or the silvered surface of the reflector affect photographic magnitudes. In certain cases the effect is so large that a comparison of results is meaningless unless the colors of individual stars are known.

[3] *H. C.* 145, p. 3.

A System of Photographic Magnitudes for the Selected Areas

BY FREDERICK H. SEARES

The normal scale has been established for each of Areas Nos. 1 to 139 separately. The reduction of the results to a uniform zero point (with which this communication is mainly concerned) has been accomplished by comparisons with the pole. To increase the precision and at the same time to afford an indication of the consistency of the results, the principles underlying triangulation operations have been applied.

Photographs of Nebulae

BY FRANCIS G. PEASE

A series of lantern slides will be shown, illustrating remarkable nebulae recently photographed with the Mount Wilson 60-inch reflector.

The Variation in Sun-Spot Activity During the Present Cycle

BY SETH B. NICHOLSON

The variation in sun-spot activity during the present cycle has been quite normal in character. Maximum occurred in the latter part of 1917, a little over four years after the previous minimum. There have been several spots large enough to be seen without a telescope. Two that appeared during 1917, in February and August, respectively, were among the largest ever recorded.

The Relation Between the Size of a Sun-Spot and the Strength of its Magnetic Field

BY SETH B. NICHOLSON

A definite relation has been found between the size of a sun-spot and the strength of its magnetic field. A curve showing this relation will be presented.

The Structure of the Emission Bands in the Spectrum of Nova Aquilae No. 3

BY W. S. ADAMS AND A. H. JOY

The spectrum of *Nova Aquilae* as photographed in February and March shows but little change when compared with that of November, 1918. The nebular bands are stronger relative to those of hydrogen but the structure within the bands is closely the same

as on the photographs taken in the late autumn. Apparently the form of these bands, therefore, represents a fairly stable condition, and it is of interest to learn whether their structure is the same for the different elements.

The bands upon which measurements were made are Hγ, 4363, 4580 to 4700, Hβ, 4959 and 5007. The band Hε is present but is too weak for measurement upon our recent photographs. All the bands show some characteristics in common, being bounded sharply on the violet edge by a bright maximum and having a number of absorption lines distributed thruout their extent. The red edges are defined by what appears to be an absorption line, but beyond this line is a small bright area which no doubt belongs to the band. The effect is seen most clearly in the case of 4363, where this bright "knob" is clearly double.

The following measures show the displacements in angstrom units of the more prominent features of these bands. The assumed normal positions of the bands are as follows: 4340.6, 4363.4, 4640, 4685.7, 4861.5, 4959.0, 5006.9. The displacements are reduced to the Sun and are corrected for the radial velocity of the star. The values for 4640 and 4686 are uncertain on account of the character of the bands. The red portions of the bands Hγ, 4640 and 4959, are overlapped by the bands following and no measures are possible. All of the maxima measured are bright.

	Hγ	4363	4640	4686	Hβ	4959	5007
Vi. edge bright band	−25.6	−25.8	−27	−28	−28.6	−29.5	−29.7
Maximum	24.9	24.9	25	27.1	27.5	28.1	28.4
Absorption line	20.1	20.9	21	22.4	23.8	....	....
Absorption line	17.0	16.8	16	18.1	18.7	19.5	18.6
Maximum	8.5	9.2	..	....	....	10.7	10.3
Absorption line	6.2	6.2	6	6.4	7.1	7.8	8.2
Maximum	4.9	4.5	..	4.3	4.9	5.2	....
Absorption line	....	− 0.3	..	− 1.5	−1.2	0.0	0.0
Maximum	....	+ 4.9	..	....	+ 3.2	+ 4.4	....
Absorption line	....	6.2	..	....	8.2	....	+ 8.7
Absorption line	....	8.6	..	+ 8.5	....	....	10.3
Absorption line	....	13.6	..	....	14.7	....	13.7
Absorption line	....	18.8	..	....	22.1	....	22.1
Maximum	....	23.4	..	....	25.0	....	25.6
Red edge bright band	....	24.0	+26	25.7	26.3	....	27.2
Absorption line	....	+24.9	..	+28	+28	....	+29

It is clear from this comparison that the structure repeats itself in the successive bands, with the displacements from the normal positions proportional to wave-length. The principal value of this

result is to show that the absorption lines are due to the elements producing the bright bands and not to foreign elements with lines greatly displaced.

Eighteen Stars with Spectra Similar to Those of the Cepheid Variables

BY W. S. ADAMS AND A. H. JOY

In a communication to the *Proceedings of the National Academy of Sciences* for May, 1918, we called attention to five stars with spectra resembling strongly those of the Cepheid variables. Observations made since that time have added considerably to their number, and we believe a publication of the list will be of interest to those engaged in determinations of radial velocity and perhaps to variable star observers as well.

The principal characteristics of Cepheid spectra are well-known. Most of them are of the general type F5 to Go with narrow, sharply defined metallic lines. The hydrogen lines, however, are much stronger than in normal spectra of this type, and the enhanced lines are quite abnormal, having several times the intensity which they possess in stars such as the Sun. In particular, attention may be called to the following enhanced lines, which are also very prominent in the spectrum of the chromosphere and in such stars as α *Cygni*.

4077 Sr 4215 Sr 4233 Fe 4246 Y 4290 Ti: 4375—
4385 Fe 4534 Ti: 4584 Fe.

As has been shown by Shapley and by Adams and Joy the intensities of the hydrogen and the enhanced lines vary with the light of the star, being stronger at maximum of light.

In the following table are given the stars with spectra having Cepheid characteristics. The successive columns give the number of the star in Boss's catalog, its name, visual magnitude, spectral type according to the Harvard observers, proper motion, galactic latitude, and spectral type according to our own determinations. It is of interest to note that four of the stars are marked F8p by the Harvard observers.

			m	Harv. Sp.	μ	b	Spectrum
Boss	619	14 Persei	5.6	F	0″.004	−14°	F9
	772	α Persei	1.9	F5	0 .039	− 5	F5
	1074	58 Persei	4.5	G	0 .025	− 4	G1
	1606	ψ^1 Aurigae	5.1	K	0 .014	+17	K3
	1839	δ Can. Maj.	2.0	F8p	0 .005	− 7	G1
	2065	ξ Puppis	3.5	G	0 .007	+ 2	G6
	2153	ρ Puppis	2.9	F5	0 .100	+ 5	F6
	4443	β Draconis	3.0	G	0 .016	+32	G1
	4707	45 Draconis	5.0	F8p	0 .011	+24	F8
	5187	o^2 Cygni	4.0	K	0 .002	+ 6	G7
	5197	α^1 Capricorni	4.6	G	0 .015	−26	G1
	5229	γ Cygni	2.3	F8p	0 .003	+ 1	F9
	5255	41 Cygni	4.1	F5	0 .010	− 6	F6
	5431	ξ Cygni	3.9	K5	0 .007	− 3	K4
	5676	α Aquarii	3.2	G	0 .015	−43	G0
	5804	5 Lacertae	4.6	K5	0 .021	−10	K2
	5931	.....	5.6	G	0 .009	− 4	G0
	6135	ρ Cassiopeiae	4.8	F8p	0 .007	− 5	G5

The spectra of these stars have been compared directly with such typical Cepheids as δ *Cephei* and ζ *Geminorum*, and the following stars have been found to have spectra which are nearly identical with them:

Boss 619, 772, 1074, 2153, 4443, 4707, 5197, 5229, 5255, 5676, 5931. The three stars 1606, 5431 and 5804 show spectra of the K type but with strong Cepheid characteristics. The hydrogen lines, for example, in these stars correspond to the spectral types G5, G5 and G3.

In addition to the similarity of spectral type these stars resemble the Cepheid variables both in their extremely small proper motions and their low galactic latitudes. With the exception of Boss 2153 there is no star in the list with a proper motion exceeding 0″.040, and there are but two stars with galactic latitudes greater than 30°.

The following stars in the list have been found to have variable radial velocities from observations at the Lick Observatory:

Boss 1606, 1839, 2153, 5187, 5431

Mount Wilson observations of Boss 1074 when compared with those published by the Lick Observatory indicate that this star also has a variable velocity. Accordingly six of the eighteen stars in the list have this characteristic, and it is possible that others might be found to have a small variation if observed with spectrographs of high dispersion over a considerable interval of time.

So far as we know only one star, Boss 6135, has been suspected of a variation in light, and no variation in spectral type has as yet been found by us. Spectroscopic determinations of the absolute

magnitudes of these stars indicate that they are all extremely bright with values ranging from -1 to -4, approximately. These values are of much the same order as the absolute magnitudes of the Cepheid variables. A few of them, in fact, such as δ *Canis Majoris*, appear to be brighter than any Cepheid we have so far investigated.

The Masses and Absolute Magnitudes of Visual Binaries

BY A. VAN MAANEN

For 36 binaries the data now available seem to give a fairly reliable determination of the mass. The results show a correlation between masses and absolute magnitudes which appears to be independent of the spectral type.

Note Relative to the Local Cluster

BY HARLOW SHAPLEY AND MYRTLE L. RICHMOND

An analysis of the stars of type B in the first two volumes of the *Henry Draper Catalog* shows that the local cluster contains few of the fainter stars of this spectral type. Diagrams will be shown illustrating the divergence of the plane of the local cluster from the galactic plane and showing the great extent of the *Perseus* clusters.

On the Source of Discordant Values for Solar Rotation

BY CHARLES E. ST. JOHN AND L. W. WARE

The differences between the rotation values found by different observers are of the order of the differences found by the same observer upon successive days and even from observations made in immediate sequence. They are greater than the errors of observation and hence have their source either in the solar or terrestrial atmosphere. Investigations now in progress at Mount Wilson Observatory indicate that disturbances in the Sun's reversing layer are occurring with great frequency, and are of such character as to affect observations near the solar limb and of an order of magnitude to produce the discrepancies observed.

Woman's Work in Astronomy

BY DOROTHEA KLUMPKE ROBERTS, D. SC.

Her work in the past—her greater work in the future—her duty toward herself and her obligations unto Astronomy for the enlightenment and betterment of mankind.

The Spectroscopic Orbit and Absolute Dimensions of the Eclipsing Variable U Ophiuchi

BY J. S. PLASKETT

By the combination of the orbital elements deduced from photometric observations with radial velocity results, the absolute dimensions, masses and densities of this system have been obtained.

The Figure of the 72-inch Mirror Under Constant and Changing Temperature Conditions

BY J. S. PLASKETT

Measurements of the zonal aberrations of the mirror by the Hartmann method were made both in the optical shop and under varying observing conditions. The change in form under average conditions both before and after the insulating protection was applied is exhibited graphically.

The Spectra of the Orion Nebula and Neighboring Nebulosities

BY V. M. SLIPHER

A preliminary note will be given on the spectra of different parts of the *Orion* nebula and of some of the associated or neighboring nebulosities. Slides will be shown of some of the more significant cases.

Appeal for Variable Star Observers

BY WILLIAM TYLER OLCOTT

Owing to the fact that at present there are practically no observers of variable stars on the Pacific Coast, the American Association of Variable Star Observers makes a special appeal to observers in this locality with telescopes of three-inch aperture or larger to join the Association and co-operate with it.

The work is of great practical and scientific value and is particularly adapted for the field work of astronomical students in our institutions of learning.

The Association issues a booklet containing instructions for observing and provides the necessary charts. All interested are requested to address the Secretary of the Association, William Tyler Olcott, Norwich, Conn.

An Automatic Optical Periodograph

BY A. E. DOUGLASS

(Abstract)

This instrument is designed for the rapid preliminary analysis of series of observations such as rainfall, temperature, variable stars, etc., into periodic and some non-periodic elements. Light is passed thru between the plotted curve and some datum line; thence thru a cylindrical lens with vertical axis. In the focal plane the curve-crests appear in light intensity. The vertical lines in the focus pass thru an analyzing plate consisting of narrow, equally spaced parallel transparent lines, tipped at a slight angle from the vertical. Interference fringes are produced which indicate the periods sought. A photograph of the interference or differential pattern so produced is used in detailed study. Condensing lenses are inserted back of the analyzing plate to carry the light thru an integrating cylindrical lens with horizontal axis which reproduces on a vertical slit at the back the summation of horizontal fringes. Back of the slit is a long photographic film mounted on the outside of a drum which rotates as the periodograph moves along its track. The track extends in a direction perpendicular to the plane of the curve in order that the size of the image in the focal plane may change thru a considerable range. The instrument is moved along the track by an electric motor and has automatic focussing and signal devices attached. The image produced on the film is the periodogram. Periods are indicated in it by a beaded or corrugated effect.

This periodograph is especially adapted to the study of cycles and has been used in investigating weather variations and periodic variations in tree growth. It has been tested in the solution of variable star periods. Preliminary forms of parts of it have been described in the *Astrophysical Journal*, October, 1914, and April, 1915.

University of Arizona.

Some Results Obtained by the Crocker Eclipse Expedition, June 8, 1918. Lantern Slides.

BY W. W. CAMPBELL AND J. H. MOORE

(Abstract)

From photographs obtained by the Crocker Eclipse Expedition to Goldendale, Washington, with cameras of focal length 4 ft., 15 ft. and 40 ft., we conclude:

1. The general outline form of the corona was more elongated east and west, with reference to its north and south dimension, than the phase of the sun-spot cycle had led us to expect.

2. The short polar streamers of the corona may be in fair agreement with the magnetic lines of force of the Sun, assuming the magnetic axis and the rotation axes of the Sun to be in approximate coincidence, but the other coronal streamers, especially for the inner and middle corona, are not in harmony with such magnetic lines. The forms of the inner coronal streamers seem to be controlled from local centers occupied by solar prominences. Nearly all of the larger prominences and some of the smaller ones are enclosed by hooded coronal forms, which extend in some cases at least ten or fifteen minutes of arc from the Sun's edge. There can be no doubt that the hooded coronal structure is intimately related to the prominences; the forces responsible for one set of phenomena appear to be responsible for both.

3. Comparison of the coronal photographs with the photographs of the photosphere, the prominences, the faculae, and the spots obtained at the Mount Wilson Observatory on June 8th and on a few days immediately preceding and following that date, has shown no apparent relationship between the hooded coronal forms and the prominences on the one hand, and the sun-spots and faculae on the other hand.

4. A comparison of the 40-foot photographs of the inner corona with similar photographs kindly supplied us by the Lowell Observatory, has shown that changes in the details of coronal structure occurred while the Moon's shadow was travelling from Washington to Kansas, but we have not been able to say that motion away from or toward the Sun has occurred.

The distribution of coronium around the Sun seems not to have intimate relationship with the distribution of the prominences and spots.

The wave-length of the green coronium line was determined to be 5303.0A.

A spectrogram of the corona recorded no absorption lines. The well known bright lines of the corona were observed and likewise a few bright lines not previously recorded.

The Einstein Effect; Eclipse of June 8, 1918

BY H. D. CURTIS

The results of measures on plates taken with the Vulcan cameras at Goldendale, Washington, at the eclipse of June 8, 1918.

Suggested Procedure for Standardizing Radial Velocity Results

BY W. W. CAMPBELL

(Abstract)

The accidental errors in radial velocity observations are relatively small, but the question of eliminating or reducing the size of systematic errors is still with us for solution. The subject should have our careful consideration, in order that radial velocities of stars determined at different observatories and with different degrees of dispersion may be combined into one harmonious system.

The so-called "Zero-Velocity" reduction table accomplishes this for Class G stars, because the actual radial velocity of the Sun, a Class G star, may be computed from the known elements of the Earth's orbit.

Reduction tables for spectra of classes F, A, B, Oe5, in so far as they consist of isolated absorption lines, depend upon the assumption that the wave-lengths of these lines, lines embracing a great variety of widths, are identical with the corresponding narrow radiation lines as observed in the laboratory. This assumption may not represent the truth, and there are some indications that it does not.

The class G reduction table serves fairly well for stars of classes K1-3, but it is more and more unsatisfactory as we proceed thru the classes K5, Ma-d, and N. The relative intensities of lines in the solar spectrum are not preserved in those of classes K5 to N. Results based upon class G tables are probably appreciably in error, and this error is liable to be especially serious when low dispersions are employed.

To eliminate the uncertainty in part, and perhaps as far as we are now able, it is recommended that two or three of the brightest stars in each of the main spectral classes K1, K5, Mb and N be observed with the highest available and practicable dispersions, preferably on medium-speed plates, in order to eliminate as many blended combinations of lines as possible. Certainly for classes K, K5, and Mb the spectrographs should have dispersion higher than the existing three-prism instruments afford, if fortunately such more powerful instruments may be available in any radial velocity observatory. On these spectrograms the lines apparently single and identical with lines in Rowland's solar spectrum should be selected for measurement, and the equivalent radial velocities be deduced on the basis of Rowland's wave-lengths (for the present). Such observations should be repeated from time to time to insure that the stellar velocities are apparently constant, and the mean values of such observations should be adopted as the most probable radial velocities of these stars.

All observers of classes K, M, and N stars, no matter what dispersive powers their instruments may have, should secure four or more thoroly satisfactory observations of some of the standard stars in each spectral class, and either make their reduction tables for each class reproduce the high dispersion standard velocities, or determine the discrepancy and apply it to each observed velocity of the stars in that class.

If measurements are to be made by the Hartmann spectro-comparator, using with each spectral class a reference plate of the same class, this plate should be compared with plates of the high-dispersion standard stars of its class, and the radial value of the reference plate be arbitrarily fixed to reproduce exactly the adopted velocities of the standard stars.

Radial Velocities of Stars of Secchi's Fourth Type

BY J. H. MOORE

Our present knowledge of the radial velocities of fourth type, or class N, stars is very limited. Only a comparatively small number of these stars are of sufficient brightness to permit of obtaining spectrograms of them with spectrographs of sufficient dispersion for reliable radial velocity determinations. Measures previously made for a few members of this class appear to be affected by uncertainties in the adopted wave-lengths, incident

to the peculiar spectra given by these stars, and the low-dispersion necessarily employed.

In the present investigation an attempt has been made to secure observations of all class N stars whose spectra can be successfully photographed, with one-prism dispersion, in the region 4400-4800A. These spectrograms have been measured on the Hartmann-spectrocomparator, using as standard comparison plates spectrograms of two class N stars whose radial velocities were accurately determined with three-prism dispersion. By this procedure, it is believed that the serious effects of uncertainties of wave-length have been reduced to a minimum.

The preliminary results of the application of this method to a number of class N stars are given.

A Periodic Variation in the Observed Latitude at Mount Hamilton

BY R. H. TUCKER

The observations of latitude for the years 1917 and 1918 have a periodic term of the form $-0''.3 \cos t$, where t is reckoned from the beginning of the year. The form of this periodic term is similar to that of one of the terms of the variation of latitude due to the motion of the pole, but the computed corrections for this variation have been applied to the original observed values of latitude, which include a more pronounced variation than that hitherto accepted.

The declinations of the fundamental stars have been examined for periodic terms depending upon right ascension. For the zone from $+40°$ to $+65°$ declination the A. G. fundamental system differs from that of the *American Ephemeris* by $-0''.14$ for the mean of 72 stars, the average residual being $\pm 0''.17$ per star. There is no distinct periodic variation in the differences.

The revised A. G. system now in use differs from the original A. G. system by $+0''.17$ for the mean of 150 stars in this zone, the average differences being $\pm 0''.34$ per star.

The revised A. G. system differs from that of the *Preliminary General Catalog* of Lewis Boss by $+0''.07$ for the mean of 150 stars in this zone, the average difference being $\pm 0''.10$. There is a periodic term of the form $-0''.054 \cos \alpha$. The old A. G. system compared with Boss has periodic terms: $+0''.16 \sin \alpha - 0''.06 \cos \alpha$. These periodic terms derived from comparison of fundamental systems of declinations are not large enough to account

for the observed variation in latitude. Nearly 1200 observations of latitude have been included in this discussion, obtained in a period of fourteen months. The observations of latitude from the circumpolar stars in the period indicate a correction of $+0''.2$ to the mean of the A. G. declinations in the zone $+40°$ to $+65°$.

The variation in the observed latitudes is too large to be ascribed to any seasonal variation in the refraction corrections, at the moderate zenith distances of this zone, and probably it can only be explained by some local conditions of a transitory character.

May 13, 1919.

Periodic Variation in the Position of the Mire at Mount Hamilton

BY R. H. TUCKER

All the observations since the year 1893 unite in giving an annual variation of approximately $0''.8 \sin t$, where t is reckoned from the beginning of the year.

Observations of a fundamental character indicated the existence of a diurnal term also, in the periodic variations.

For ten years, 1893 to 1903, there was no sensible change in the mean position. From 1903 to 1912 there was a progressive secular change of $-0''.6$ per year. Since 1912 there has been no sensible change in the mean position.

Periodic changes in position are to be explained probably by the effects of temperature upon the south slope of the mountain, near the edge of which the pier for the mire is located.

May 13, 1919.

A Few Results of the Recently Completed Program of Radial Velocity Measurements of the Bright-Line Nebulae

BY W. W. CAMPBELL AND J. H. MOORE

(Abstract)

The program for the determination of the spectrographic velocities of the bright-line nebulae, from observations secured at Mount Hamilton and at our branch observatory at Santiago, Chile, was completed last year for all known objects of this class bright enough to be observed with exposure times of practicable length. A few of the statistical results of this investigation are as follows:

1. The radial velocities of 125 bright-line nebulae have been determined.

2. In addition to the 18 nebulae in the Magellanic Clouds, there are six planetary nebulae whose observed radial velocities exceed ± 115 km/sec. It is interesting to note that these six are located in a very small area of the sky (R. A. = 15.1 to 19.2 hours; Decl. = $-9°$ to $-30°$).

3. The remaining 101 observed nebulae yield a speed of -23.6 km/sec. for the motion of the solar system with reference to them as a system, assuming the apex of motion to be at R. A. = 270°, Decl. = $+30°$. The system of 101 nebulae as a whole is therefore substantially at rest with reference to our stellar system.

4. The average radial velocity of the five extended irregular nebulae with reference to the stellar system is ± 11 km/sec. Excluding the 18 Magellanic nebulae, the average radial velocity of the 102 planetary nebulae outside of the Magellanic Clouds is ± 37 km/sec. If we also exclude the other six nebulae (planetaries) which have very high velocities, the average velocity of 31 planetaries whose diameters are less than 5 seconds of arc, and which have been called "stellar" nebulae on that account, is ± 28 km/sec., and that of the other 65 planetaries (whose diameters are greater than 5 seconds) ± 31 km/sec. The stellar nebulae are found exclusively in one quadrant of the Milky Way.

5. The evidence for a Kapteyn preferential motion of the bright-line nebulae is present if we include the group of six high-velocity planetaries, and is essentially absent if we exclude the six.

A Study of Certain Nebulae for Evidences of Polarization Effects

BY W. F. MEYER

(Abstract)

The spiral nebulae and certain types of extended irregular nebulae present conditions which have led some astronomers to suggest that these objects may be shining by reflected light. The original source of illumination, under this hypothesis, is assumed to be in the nuclei of the spirals and in the stars within or near the extended nebulae, and the nebular materials polarize by reflection and diffusion the rays of light falling upon them. Some of the conditions which suggest the reflection hypothesis are:

1. Nearly all of the spirals have spectra closely resembling the

spectra of yellow stars, and a few of the extended nebulae show the same types of spectra as the stars apparently involved in them.

2. A few nebulae which involve stars known to be variable have spectra of the same types as the stars, and these nebulae also vary in brightness and apparent form. It is postulated that these nebulae receive their light in whole or in large measure from the variable stars within or relatively near them.

3. Those spiral nebulae which are seen edgewise or nearly so, show each a dark lane superimposed upon its image and parallel to the direction of its greatest dimension. This phenomenon, some have suggested, may possibly be explained by the reflection hypothesis. The parts or particles of such a nebula which lie nearest to us should, on this hypothesis, be bright on the faces turned away from us and toward the radiating nucleus, and relatively dark on the faces turned toward us.

A study of representative spiral and variable nebulae for evidences of polarized light is very desirable, in order to test the reflection hypothesis of the origin of their light. For this purpose a polarigraph was designed for use in connection with the Crossley reflecting telescope. Nebulae of both types were photographed in duplicate by means of this optical combination; each nebula once with the principal plane of the analyzer coinciding with a given diameter of the object, and again with the principal plane at right angles to this position. The pairs of images were examined with the Hartmann microphotometer to detect differences of intensities along the two diameters of the nebular images.

To test the sensitiveness of the polarigraph, extensive laboratory experiments were made with different percentages of plane-polarized light. As a further test, "artificial" nebulae were illuminated with polarized light, so as to reproduce as nearly as practicable the appearance of the objects studied. As a result of the laboratory experiments, it was concluded that if as much as ten per cent of the light in each image were plane-polarized, this property would not escape detection.

At least twelve nebulae were satisfactorily photographed and their images critically examined. In no instance was the evidence of polarization sufficient even to suspect its presence. We conclude that if some of the light coming from the nebulae under investigation is modified by reflection or scattering by small particles, the proportion of light thus polarized is less than ten per cent of the light received from these objects.